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RESEARCH PAPER

Practical Application of Multivariant Analysis Techniques to the Forest Management of Active Farmers in the Northwest of Spain

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Abstract As managers almost exclusive in many worldwide forestry regions, non-industrial private forest (NIPF) owners come to play a key role in balanced integrating the variety of forest uses and functions in policies for promoting and revitalising rural areas. In Galicia, a region in the Spanish Northwest, over 67.5% of forestland and 80% of woodland is managed by NIPF owners. Almost 40% of the Galician NIPF owners are agricultural or livestock farmers who manage a total of 169,755 agrarian holdings with woodlands. Although the number of agricultural holdings has dropped significantly over the last 60 years, farmers still constitute a representative section of the NIPF owner population in Galicia. Starting from an initial population of 31,285 active full-time professional farmers in the region, and based on data collected by a personal questionnaire from a sample comprising 4,383 of these professional farmers for the period 1993–2003, Discriminant Analysis (DA) was used to identify which socioeconomic, territorial and public-political factors were useful in distinguishing, and to what extent, that a certain population of Galician active farmers should opt to own and manage forestland areas within their agrarian holdings. The results suggested that the forestry production capacity for the area in which the agricultural holding is located, the size and the number of plots in the land base, the number of years the farmer has been the owner and the economic yield from the holding over the total family income were key factors in distinguishing between farmers with forestry activity (*forestland owners*) and farmers with no forestry activity (*farmland owners*). These findings could be used as a guide for designing, planning, and implementing research and policy measures that could

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allow NIPF landowners with farming and livestock activity to develop sustainable forestry, as key agents in promoting rural development.

Keywords Farmer · Discriminant analysis (DA) · Forest management · Non-industrial private forest (NIPF) owners

Introduction

As a result of increasing urban and industrial development during the mid-19th century, traditional agricultural and forestry activities were no longer economically viable for many rural communities, and the active population largely shifted to urban agglomerations. The gradual disappearance of the rural heritage has resulted in a reduction of agricultural practices and in landscape-scale land retirement modelled only by aging residents (Marey-Pérez and Rodríguez-Vicente 2008). Consequently, the forest management and planning, as an indisputable part of the set of natural resources, is starting to be an object of study and international debate, both in the technical-scientific field and in public-political matters, on different working scales and in different disciplines (Johann 2007; Church and Ravenscroft 2008; Parker et al. 2008; Bergseng and Vatn 2009; Munton 2009; Teixido et al. 2010; Vokoun et al. 2010). The inherent complexity associated to forestry management, evident in the extensive bibliography on the matter, points that the new forest management paradigm has been transformed from timber management to forest ecosystem management, from sustained timber yield management to sustainable forest management, and from forest management by exclusion to management by inclusion of user groups (Kant 2003). Society's constant demands for sustainable forest management, and the key role of forestry in the oft-mentioned rural development, have entailed, and will continue to entail, constant changes in forestry patterns, and consequently, constant adaptations to the owner profiles and their forest management objectives and goals.

Thus, developing realistic, effective policies for sustainable land management and planning require to be constantly updated on the scientific literature available regarding the different forest management guidelines for the different owner profiles. Consequently, there is a growing international awareness on the part of forest scientists and policy makers of the significance and relevance of traditional knowledge, dependence and utilisation practices in forestry, as well as the need to take account of them in the development of political strategies aimed at sustainable forest management (Johann 2007). Nonetheless, as a result of different change processes, a more detailed analysis of forestry on different temporal and spatial scales shows disparity in the forestry variables under different regimes of ownership (Marey-Pérez et al. 2006). As Munton (2009) asserts, landowners remain key actors in understanding land-use change because of the rights they hold, and the complexity of land-use systems ranges from the human decision level to human interactions to effects over space, time and scale (Parker et al. 2008). In short, the study of how different types of owners differ in terms of use, valuation and management of forestland is needed, since using the same yardstick for preparing

management strategies and policies would thus be neither productive for the activity in itself, nor would it provide benefits for society in general (Schelhas et al. 2003).

Within this international debate for the public, scientists, and decision-makers, the so-called non-industrial private forest (NIPF) owners receive special attention, -as managers almost exclusive in many worldwide forestry regions-, and come to play a key role in balanced integrating the variety of forest uses and functions in policies for promoting and revitalising rural areas. Thus, forest management decisions are aimed primarily by the owners' motivations -values and objectives- (Karppinen 1998; Kuuluvainen et al. 1996), and accordingly, owners' forest management behaviour differs on the basis of the underlying differences regarding their motivations. Whether the forestland is managed principally for productive or non-productive aims will clearly depend of the owner objectives (Arano and Munn 2006; Majumdar et al. 2008; Joshi and Arano 2009). In short, the NIPF forest management pattern must not be interpreted as the isolated behaviour of "individuals" since the underlying differences with regard to motivations, besides responding to their own knowledge and experience, are also the result of pooling joint and not individual experience and know-how. As authors such as Schelhas et al. (2003), Bergseng and Vatn (2009) and Vokoun et al. (2010) point out, the values and decisions of forest owners with regard to their properties are complex, they are not static or isolated, rather they are influenced by and reflect proximate, dynamic social processes.

Starting from the complex diversity among NIPF owners and, therefore, from the broad range of motivations and values in forest management, active farmers or descendents of farmers comprise a significant proportion of these forest owners who, with different rights of ownership and management, play an important part in land use and planning, by maintaining or increasing the current value of the forestry sub-sector. With regard to the previous point, we could add that, as many rural areas are progressively losing their resident population, one scientific and political challenge is to guarantee the balanced capitalisation of abandoned land by combining agro-livestock and silvicultural practices within agrarian holdings. Thus, the international scientific literature cites the representiveness of agricultural or livestock farmers in the forest ownership, given the close relationship between agriculture, livestock and silviculture, distinguishing the forest management carried out by these managers with regard to other types of NIPF owners (Hyberg and Holthausen 1989; Karppinen 1998; Kurttila et al. 2001; Reid and Stephen 2001; Kuuluvainen and Salo 1991; Hardie and Parks 1996; Zhang and Mehmood 2001; Church and Ravenscroft 2008; Rodríguez-Vicente and Marey-Pérez 2008; Munton 2009; Rodríguez-Vicente and Marey-Pérez 2009a, b).

The aim of the present study is to provide useful, detailed, empirical information to analyse the forest management patterns conducted by active professional farmers in the Autonomous Community of Galicia, in the northwest of Spain. Thus, in 2002 the Department for the Rural Setting of the Galician Regional Government and the University of Santiago de Compostela agreed to conduct a research project to identify and relate characteristics linked to the managers or owners themselves (owner profile and family unit), to the land system managed (land use and agroforestry holding), and the public/political setting (communication and training

media, lines of financial incentives, land management and planning projects, among others). This would determine and significantly influence a certain population of farmers to opt for silviculture as a source of supplementary income to the household income, permitting their empirical differentiation and modelling with regard to those farmers who focus the land production and management on agriculture or livestock.

In summary, empirically characterising and quantifying the forestry management pattern developed by active farmers, as a clearly distinguible typology of NIPF owners, would enable to design public initiatives or programmes in line with their needs, objectives and expectations with regard to the land. Consequently, and within the complex framework of rural development, the productivity of agroforestry holdings would be improved, encouraging sustainable forest management compatible with other land-use alternatives.

Materials and Methods

Study Area

With a population of approximately 2,800,000 inhabitants and an area of 29,500 km^2, Galicia (Fig. 1) is one of the most densely populated Autonomous

Fig. 1 Location of the autonomous community of Galicia in Spain

Communities in Spain. Two thirds of Galician population is shared out among 30,000 rural settlements (INE 2005). The high number of population settlements (almost one nucleus/km^2, accounting for 50% of all population settlements in Spain), along with the high density and population dispersion (93 inhabitants/km^2), indicates that Galicia is one of the most homogenously populated regions in Europe (Marey-Pérez and Rodríguez-Vicente 2008; Teixido et al. 2010).

These rural areas include an enormous variety of cultures or know-how, landscapes and socioeconomic activities which jointly form a wide range of predominantly agricultural entities. In consequence, agrarian activity is also characterised by an enormous diversity of land uses and organisational structures (Álvarez-López et al. 2008; Riveiro et al. 2008), although less than 30% of Galician territory is agro-livestock land and only 32% of the region's population live in rural areas and have agriculture as their principal source of family income (de Galicia 2001). As proof of the above, the official data of the current Agricultural Census indicate that the number of agrarian holdings in Galicia dropped by somewhat more than 163,600 during 1962–1999, i.e. a decline of 37.7% (INE 1962, 1999). Accordingly, this decline in the number of agrarian holdings was accompanied by an important reduction in the land base; almost 383,000 ha and 4.9 million plots ceased to be officially included in the regional agricultural statistics, 15.8 and 50.6% of the area and number of plots recorded in 1962, respectively (INE 1962, 1999).

Arable or livestock farming, combined with forestry, has been the main means of subsistence for Galician rural communities until the mid-20th century, in a multi-purpose management system that is considered sustainable in many rural regions (Marey-Pérez et al. 2006). In this Galician agrarian system, the forest was an essential part of the land uses in agro-livestock holdings, allowing its managers to obtain additional family income to complement an agro-livestock production, -which was generally unspecialised in one single product-, and being active capital to be transmitted from generation to generation within the family unit. This traditional system of acquiring land through inheritance and allotment has shaped the current Galician agrarian landscape, which is divided into an enormous number of plots, with different mixes of land uses (Marey-Pérez et al. 2006).

The Third National Forest Inventory sets the current Galician forestland in somewhat more than 2,000,000 ha; i.e., 69% of the total area of the region (MMA 1998). This public source indicates that Galician wooded forestlands, with different forest composition and silvicultural structure, account for 1.4 million ha (47.5% of regional area and 68.9% of its forest area). Galicia's forest productive capacity or potential is moreover evident in the standing timber volume; with more than 133 million m^3 over bark (a mean volume of 378.3 m^3 cc/ha), it is the Spanish community with the greatest annual volumetric growth (over 12 millions of m^3/year). Galician forests contribute 22% to the Spanish Final Agrarian Production, a percentage which acquires greater relevance taking into account that Galicia's forestry stands represent 2% of the Spanish agrarian sector. Moreover, the key role of forestry resources in the Galician rural economy is ultimately evident in its contribution to the Net Present Value and the region's employment rate, both at 4% of the total generated in Galicia (Chas et al. 2002).

But without doubt, the most outstanding feature of rural Galician areas, as in many other European regions, is focused on its land ownership regime. In figures, over 67.5% of forestland and almost 80% of woodland in Galicia is owned by NIPF owners, with an average size per individual forest holding of between 1.5 and 2.0 ha. These are, in turn, divided into various plots, with a mean size of 0.23 ha per forest plot (MMA 2002). Almost 40% of the Galician NIPF owners are agricultural or livestock farmers who manage a total of 169,755 agroforestry holdings, i.e. woodlands are a part of the land base in the 64.8% of regional agrarian holdings (INE 1999). The mean woodland managed by this type of NIPF owners accounts for approximately 25% of the holding area and almost 20% of the Galician woodland (INE 1999).

Preparation of Questionnaire and Data Collection

The study population was focused on full-time Galician farmers whose principal economic income within the family unit comes from agriculture, livestock or silviculture. The documentary basis used for the proper identification of these owners was the so-called Special Agrarian Regime (Régimen Especial Agrario-REA) from the Spanish Government's Ministry of Health. This was subsequently completed with the information available on agroforestry holdings in the Land Registry of the Spanish Government's Ministry for Economic Affairs and Finance. The REA is a national public register which takes a census of farmers (both self-employed and contracted) linked professionally to agrarian activity in Spain (agriculture, livestock and silviculture). Conversely, the Land Registry is also a national public source for tax purposes, which registers the land ownership, including characteristics such as the economic value and uses, among other data of interest. Therefore, both public sources guaranteed that the study owners were professional farmers. On the basis of these official statistics, the initial population comprised a total of 31,285 active, full-time, professional farmers who jointly managed 268,661 ha of agricultural land in Galicia (Álvarez-López et al. 2008).

Based on the main objective of the research, and within subjective description methods, we opted to use a personal questionnaire applied to a statistical sample, a basic instrument in research and decision-making for any field of enquiry. Starting from the existence in Galicia of 3,793 parishes (geographical areas, without legal-administrative entity, defined according to common socioeconomic and territorial features) and 21 agroforestry districts (geographical areas of similar relief, climate, soil and agrarian potential/productivity), we opted for probabilistic sampling methods with the aim of guaranteeing an accurate, balanced territorial distribution of the sampled farmers in Galicia. This methodology is based on the principle of equiprobability, i.e. all individuals in the population have the same probability of forming part of the sample, thus guaranteeing its representativeness. Within probabilistic sampling methods, we used a random sample stratified by means of a proportional assignation technique, i.e. the number of farmers to be sampled randomly by stratum would be assigned in proportion to the size of the corresponding stratum with regard to the total parish population.

The method established a minimum of two personal questionnaires per parish, and a larger number of questionnaires for parishes with more farmers registered

under the SAS. The sample size was designed to achieve a statistical confidence level of 95% ($k = 1.6$), where the statistics p and q were equal to 0.5%. Considering the study population and the sampling methodology selected, the final size included a total of 4,383 professional farmers, 14.1% of the full-time active professionals officially registered in Galicia. The sample study was distributed randomly throughout the 3,793 parishes and the 21 agroforestry districts in Galicia, managing jointly more than 26,600 and 8,610 ha of farming and forest areas, respectively. The sampling error was 1.15%.

With regard to the structure of the personal questionnaire and the type of gathered information, a variety of questionnaires were tested before deciding on a final version, which would accurately describe and examine the land management behaviour among the study population for the 1993–2003 period. Thus, the definitive personal questionnaire contained 11 large thematic blocks, 62 questions, both open and closed, and 130 possible responses, to obtain socioeconomic information from the farmers themselves (owner profile and family unit), the land system (land use and agroforestry holding), and the public/political setting (communication and training media, lines of financial incentives, land management and planning projects, among others).

The personal interviews were conducted in 2004 by a team of 43 researchers from the University of Santiago de Compostela, all with academic training in the agrarian sector and experience in survey management. After performing the personal interviews and collecting the necessary information, the quality of the survey methodology employed and the data collected were tested by sampling 10% of the completed questionnaires within the framework of performance control and data coherence (missing and inaccurate data during the survey collection phase, i.e. non-sampling errors: coverage, non-response and response errors).

The analysis variables considered in the present study were chosen in relation to the information obtained in the personal interviews; the information was redefined and coded into nominal, ordinal or binary variables that summarized data from the survey, without losing any information of interest or research quality, and met the assumptions of the statistical analyses selected according to the typology of the variable defined. This redefinition and codification process gave rise to a data matrix comprising 251 fields (variables) and 4,383 records (farmers), a database designed with the final aim of characterising and analysing forest management in Galician agrarian holdings.

Empirical Structure of The Study

According to the nature of the data matrix and the principal objective of the study - to examine statistical differences among active farmers with and without forestland based on socioeconomic, territorial and public-political factors and, subsequently, to build an empirical quantification model-, we opted for the Discriminant Analysis (DA) as the technique most suited to this classification or differentiation of NIPF owners (Greene and Blatner 1986; Rencher 1998).

In this way, Mahapatra and Mitchell (2001) used this methodology to assess the socioeconomic factors that influence forest plantation by smallholder farmers in

Orissa (India). In Mississippi (USA), Arano et al. (2004) used DA to examine forest regeneration behaviour of NIPF owners after timber harvesting, in relation to sociodemographic characteristics. Ingemarson et al. (2004) used stepwise discriminant analysis to examine nature conservation and production goals in forest management plans in Sweden. Finley (2006) and Finley et al. (2006) used multiple discriminant analysis to evaluate interest in cross-boundary cooperation, and differences in values and attitudes toward government control, privacy and environmental protection, respectively, in private forest owners in Massachusetts (USA).

The DA is a multivariate analysis technique for simultaneously examining the differences between two or more groups of objects which are distinguished on the basis of a specific character (*criterion variable*) with respect to a group of explanatory or predictive variables (*discriminant variables*), and also to predict the membership of such objects to a specific group on the basis of the values and the relations between explanatory variables when these correspondences are completely unknown a priori (Klecka 1980). Huberty (1994) suggested that discriminant analysis techniques are appropriate when the groups of units are known in advance and the purpose of the research is either to describe differences in groups or to predict group membership on the basis of response variable measures.

In short, the DA determines which discriminant variables improve differentiation between two or more mutually exclusive and predefined groups, on the basis of a criterion variable, in order to then be able to build an empirical classification model which can be applied to other similar populations (internal and external validity). A DA model must be easy to apply, have a high ratio of prediction and a low error, and not contain a great number of variables (Mahapatra and Mitchell 2001).

Starting with n groups in which a series of objects and with k variables measured over them are assigned, the DA endeavours to obtain for each object a series p scores which will indicate their membership group by means of the so-called Fisher's discriminant function, such that:

$$\begin{aligned} L_1 &= p_{11}x_1 + p_{12}x_2 + \cdots + p_{1k}x_k + a_1 \\ L_2 &= p_{21}x_1 + p_{22}x_2 + \cdots + p_{2k}x_k + a_2 \\ &\qquad\qquad\qquad\qquad\qquad [\ldots] \\ L_n &= p_{n1}x_1 + p_{n2}x_2 + \cdots + p_{nk}x_k + a_k \end{aligned}$$

where L_1, L_2, …, L_k is the *linear discriminant function;* p_1, p_2, …, p_k, are the *discriminant scores;* x_1, x_2, …, x_k, are the *discriminant variables;* and a_1, a_2, …, a_k, are *constant terms.*

According to the measure of generalised squared distance (Rao 1973), the discriminant function must be designed to ensure maximum distance between the centroids of each group, i.e. the differences between the mean discriminant scores for groups must be as large as possible. Hence, an observation will be classified in one of the groups if its distance to the square with regard to the centroids of the group is minimal. This enables the groups under analysis to be differentiated as far as possible by maximising the inter-group variance and minimising the intra-group variance.

Based on the structure of the present study, the criterion variable selected was the forest area owned and managed by the study farmers within their agrarian holdings: FOREST criterion variable. This variable was defined as a binary response variable, taking the value '1' if farmers owned and managed forestland within their holdings (*forestland owners)*, and '0' otherwise (*farmland owners*). With regard to the prediction or discriminant variables, a total of 29 predictors from the data matrix were selected for constructing the discriminant model, adding a new predictor that represented the forestry productivity of the area in which the studied holding was located. The list of predictors grouped into four large thematic blocks, as well as the definition and codification, is given in Table 1.

The characterizing of land decision-making and management by NIPF owners according to socioeconomic, territorial and public-political factors seems consistent across the broad range of international literature: NIPF management has usually been linked to or dependent on personal or family knowledge and needs, on land ownership attributes, and on local or political context, for several generations. Thus, identifying and quantifying the relevance of these characteristics on forest decision-making and management becomes a key argument, not only for providing a richer and better understanding of the land behaviour of NIPF owners, but also for improving the current situation and prospects of this type of forestry as a decisive engine in rural areas (Rodríguez-Vicente and Marey-Pérez 2008).

Thus, in relation to the holding characterisation, the land productivity of the district where the property is located, and consequently its production orientation, seems to be a significant factor influencing the NIPF owner's forest management practices (Munn et al. 2002; Conway et al. 2003; Størdal et al. 2004; Arano and Munn 2006; Álvarez-López et al. 2008; Riveiro et al. 2008; Størdal et al. 2008; Majumdar et al. 2009). Moreover, most of the existing literature identifies land size and the degree of parcellation as the most relevant factors affecting forest management. Thus, larger areas of forestland are more likely to invest in land with forest plantations as capital (Löyland et al. 1995; Hardie and Parks 1996; Zhang and Pearse 1997; Arano et al. 2004), and are also more suitable for carrying out other types of forestry practices, such as forest improvement treatments and timber harvesting (Hyberg and Holthausen 1989; Kuuluvainen and Salo 1991; Löyland et al. 1995). Land parcellation may lead to some structural difficulties for forest investment and management, due to the small size of tracts. Hence, an increase in management costs and a decline in productive yields may be expected (Conway et al. 2003; Potter-Witter 2005; Bolkesjø et al. 2007; Størdal et al. 2008; Rodríguez-Vicente and Marey-Pérez 2009a). In addition, the patterns of land acquisition and future transmission may be important indicators of owners' decision making, especially for long-term investments, such as forestry (Hardie and Parks 1996; Conway et al. 2003; Marey-Pérez et al. 2006). According to the aforementioned authors, maintaining the viability of the property by land management by future landowners through inheritance may be key in securing the continuity of the forest sector.

However, NIPF owners' commitment to and involvement in land-use and management stems from a dynamic environment in which personal and family decisions and/or needs and policy guidelines are also closely interrelated with the geographical context (Rodríguez-Vicente and Marey-Pérez 2009a). Accordingly,

Table 1 Study discrimination variables

Predictor	Definition. Codification		Farmer classification	
			No *farmland owners*	No *forestland owners*
Holding characterization				
PRODUCTIVITY	Classification of forest productivity of the area in which the agroforestry holding is located			
Ordinal	1	Very low	229	168
	2	Low	294	203
	3	Medium	774	729
	4	High	525	570
	5	Very high	409	482
PRODUCTION	Principal productive orientation of the agroforestry holding			
Nominal	1	Private consumption by the family unit	412	419
	2	Horticulture	117	65
	3	Fruit growing	3	2
	4	Viticulture	184	100
	5	Floriculture	34	15
	6	Other agricultural productions	2	2
	7	Bovine	1,300	1,436
	8	Ovine and goat	88	58
	9	Pig	29	16
	10	Poultry	38	21
	11	Rabbit	15	10
	12	Other livestock	5	1
	13	Honey and derived products	1	1
	14	Forestry (timber)	3	6
SIZE	Area of the agroforestry holding, in ha ($x = 8.03$ ha; SD = 11.04 ha)			
Ordinal	0	If agroforestry holding did not have own land (rent)	614	0
	1	Less than 8.03	1,040	1,126
	2	Between 8.03 and 19.07	436	683
	3	Between 19.08 and 30.12	101	243
	4	Between 30.13 and 41.17	22	60
	5	More than 41.17	18	40
PLOT	Number of plots on the agroforestry holding ($x = 20$ plots; SD = 33 plots)			
Ordinal	0	If agroforestry holding did not have own land (rent)	614	0
	1	Less than 20	1,132	1,069
	2	Between 20 and 53	395	898
	3	Between 54 and 87	68	137
	4	More than 87	22	48

Table 1 continued

Predictor	Definition. Codification		Farmer classification	
			No *farmland owners*	No *forestland owners*
INHERITANCE	Acquisition of the agroforestry holding by inheritance			
Binary	1	If the farmer inherited the agroforestry holding	1,706	1,781
	0	Otherwise	525	371
PURCHASE	Acquisition of the agroforestry holding by purchase			
Binary	1	If the farmer bought the agroforestry holding	234	153
	0	Otherwise	1,997	1,999
ACQUISITION	Acquisition of the agroforestry holding by inheritance and purchase			
Binary	1	If the farmer inherited and bought the agroforestry holding	154	144
	0	Otherwise	2,077	2,008
CREATION	Agroforestry holding of new establishment			
Binary	1	If the agroforestry holding was established by the farmer	118	58
	0	Otherwise	2,113	2,094
RENT	Agroforestry holding acquired by renting			
Binary	1	If the farmer rented the agroforestry holding	19	16
	0	Otherwise	2,212	2,136
Farmer profile				
GENDER	Gender of the farmer			
Binary	0	Female	1,320	944
	1	Male	911	1,208
AGE	Age of the farmer, in years ($x = 49.5$ years; SD = 11.8 years)			
Ordinal	1	Between 18 and 35	245	196
	2	Between 36 and 55	1,113	1,126
	3	Between 56 and 65	794	798
	4	More than 65	79	32
EDUCATION	Level of formal education received by the farmer			
Ordinal	1	No formal education	381	343
	2	Primary education	1,622	1,619
	3	Secondary education	212	168
	4	Tertiary education	16	22
MANAGEMENT	Management of the agroforestry holding by the farmer, in years ($x = 22$ years; SD = 14 years)			
Ordinal				
	1	Less than 8	444	339
	2	Between 8 and 22	863	781
	3	Between 23 and 37	531	603
	4	Between 38 and 52	385	417
	5	More than 52	8	12

Table 1 continued

Predictor	Definition. Codification		Farmer classification	
			No *farmland owners*	No *forestland owners*
TIME1	Percentage of personal labour-force spent annually on the agroforestry holding between 1993 and 2003 ($x = 95.0\%$; SD = 18.4%)			
Ordinal	1	Less than 35,7	83	64
	2	Between 35,7 and 65,3	77	87
	3	Between 65,4 and 95,0	12	21
	4	More than 95,0	2,059	1,980
TRAINING	Agroforestry training received by the farmer			
Binary	0	Otherwise	1,621	1,451
	1	Participación in an agroforestry course	610	701
CONDITIONING1	Role of agroforestry training in encouraging holding management			
Ordinal	1	No agroforestry training. Null	1,760	1,655
	2	Scarce	250	268
	3	Noteworthy	221	229
Family unit				
FAMILY	Number of members, ascendant and descendant, who form part of the family unit ($x = 4$ members; SD = 2 members)			
Ordinal	1	Less than 2	87	59
	2	Between 2 and 4	1,394	1,273
	3	Between 5 and 7	696	773
	4	More than 7	54	47
TIME2	Number of relatives, ascendant and descendant, annually working on the agroforestry holding between 1993 and 2003 ($x = 1$ relative; SD = 1 relative)			
Ordinal	0	None	1,811	1,684
	1	Less than 2	260	278
	2	More than 2	160	190
CONDITIONING2	Role of family labour-force in encouraging holding management			
Ordinal	1	None. null	1,887	1,782
	2	Scarce	226	241
	3	Noteworthy	118	129
INCOME1	Annual net family income between 1993 and 2003, in Euros ($x = 14{,}447$ €; SD = 2,811 €)			
Ordinal	1	Less than 10,800	950	906
	2	Between 10,800 and 21,600	1,039	1,055
	3	More than 21,600	242	191
INCOME2	Percentage of agrarian income with regard to the total annual net family income between 1993 and 2003 ($x = 49.8\%$; SD = 36.9%)			
Ordinal	1	Less than 12.9	667	509
	2	Between 12.9 and 49.8	299	337
	3	Between 49.9 and 86.8	755	791
	4	More than 86.8	510	515

Table 1 continued

Predictor	Definition. Codification		Farmer classification	
			No *farmland owners*	No *forestland owners*
REPLACEMENT	Existence of generational replacement of the agroforestry holding			
Binary	0	No	1,457	1,390
	1	Yes	774	762
Factors outside the agroforestry holding, farmer or family unit				
AGRICULTURE	Existence of other agricultural and livestock uses that severely compete with the principal productive orientation of the agroforestry holding			
Binary				
	0	No	2,228	2,148
	1	Yes	3	4
FORESTRY	Existence of forest uses that severely compete with the principal productive orientation of the agroforestry holding			
Binary				
	0	No	2,044	1,940
	1	Yes	187	212
URBAN	Existence of urban or industrial uses that severely compete with the principal productive orientation of the agroforestry holding			
Binary				
	0	No	2,196	2,093
	1	Yes	35	59
CONDITIONING3	Degree of land-use competence with the principal productive orientation of the agroforestry holding			
Ordinal				
	1	None. null	1,962	1,845
	2	Scarce	133	134
	3	Noteworthy	136	173
SUBSIDY	Formal application for an agroforestry subsidy between 1993 and 2003			
Binary	0	No	2,173	2,076
	1	Yes	58	76
CONDITIONING4	Degree of dependence on agroforestry subsidies for holding management			
Ordinal	1	None. null	1,292	1,198
	2	Scarce	314	297
	3	Noteworthy	625	657
TIME3	Number of professional employees, temporary and permanent, annually contracting on the agroforestry holding between 1993 and 2003 ($x = 1$ employee; SD = 1 employee)			
Ordinal				
	0	None	1,878	1,799
	1	Less than 2	253	289
	2	More than 2	100	64
CONDITIONING5	Role of professional assistance in holding management			
Ordinal	1	None. null	1,899	1,838
	2	Scarce	192	204
	3	Noteworthy	140	110

Differentiation between *farmland* and *forestland owners*

landowner attributes (gender, age, level of education, and agroforestry training, among others) are usually interpreted as the owner's ability to manage the existing resources and value them as new opportunities or management challenges (Rodríguez-Vicente and Marey-Pérez 2009b). Moreover, landowners who rely on forest management and monitoring and attempt to involve their family in these activities are generally more able to take advantage of forests and have a more favourable attitude towards adopting sustainable forestry (Hardie and Parks 1996; Rodríguez-Vicente and Marey-Pérez 2008). In this way, the behaviour of the forest management is usually related to the household earnings and the role of dependency on forest products in order to support the family's well-being (Mahapatra and Mitchell 2001; Arano et al. 2004). The personal and family commitment to land management may also be supported by hiring professional assistance in forestry, encouraging and conducting forest management (Hardie and Parks 1996; Zhang and Flick 2001). Finally, the role of land management and planning policy, especially public subsidies, receives considerable research attention as measures that can encourage or limit-discourage land investment and maintaining of the productivity of the land by means of land-use changes or future intentions (Rodríguez-Vicente and Marey-Pérez 2009a).

The significant prediction variables in differentiating profiles in NIPF farmers with regard to forestry management were included in the discriminant function by means of backward stepwise selection. Starting with the discriminant variable which best differentiated between groups, the validity of each predictor in the discriminant function was evaluated by means of Wilks' Lambda λ criterion (Wilks 1932), analysing the change in value of its associated Snedecor's F statistic when incorporated into the model: those predictors which produced greater changes in Lambda and, thus, greater changes in F, were consequently incorporated into the discrimination model. The input and output criteria selected were values greater than 3.84 and lower than 2.71, respectively. In turn, the analysis of multicollinearity between prediction variables was based on Box's M test, verifying the equality of variances-covariances or correlations between the different groups of observations. Finally, the validity of the constructed discriminant function was reinforced and tested by removing noise variables (Huberty 1994), stepwise iteration and conducting split design test (Lachenbruch 1975).

The total study sample (4,383 full-time active farmers) was divided into two different subsets, namely, a test sample (3,489 farmers) and a calibration sample (894 farmers), in order for the first subset to act as the basis for constructing the linear discriminant function and, subsequently, the second would make it possible to validate said function, internally and externally, as a predictive classification model.

The series of technical statistics performed in the present study was conducted with *R* statistical software, version 2.10.1.

Results and Discussion

On the basis of the FOREST criterion variable, the sample was grouped a priori into 2,231 *farmland owners* and 2,152 *forestland owners*. The principal characteristics of the agroforestry holdings in the study, differentiated on the basis of the classification

of farmers into *farmland* and *forestland owners*, are shown in Table 2. Nonetheless, as mentioned above, the construction of a discriminant function for verifying how and to what extent *farmland* and *forestland owners* were differentiated in the study region according to socioeconomic and territorial attributes was constructed with 80% of the initial sample (3,489 farmers), classified into 1,776 *farmland owners* and 1,713 *forestland owners*. The remaining 20% of cases (894 farmers), classified into 455 *farmland owners* and 439 *forestland owners*, made it possible to subsequently evaluate and interpret the predictive power of the discriminant function.

Through an iterative process by steps, a total of five variables were selected to construct the model for discriminating between *farmland* and *forestland owners* (Table 3): three were linked to the holding (SIZE, PLOT and PRODUCTIVITY), and two linked to the owner and family unit (MANAGEMENT and INCOME2):

$$\begin{aligned} \text{FOREST} = & -3.157 + 0.324\ \text{PRODUCTIVITY} + 0.504\ \text{SIZE} + 0.907\ \text{PLOT} \\ & + 0.210\ \ \text{MANAGEMENT} - 0.128\ \text{INCOME2} \end{aligned} \quad (1)$$

Table 3 shows the principal results obtained with the application of discriminant analysis to the study population. As regards the degree of canonical correlation (0.743), a measurement of the association between the discriminant scores and the farmer groups, we can say that the discriminant function constructed differed greatly between *farmland* and *forestland owners* in the region under study.

Table 2 Principal characteristics of the agroforestry holdings in the study

Attribute	Farmer classification	Descriptive statistics	
		x	SD
Area of the agroforestry holding, in ha	*Farmland owner*	5.53	10.58
	Forestland owner	10.63	10.91
No. of plots on the agroforestry holding	*Farmland owner*	14	36
	Forestland owner	26	28
Mean size of plots on the agroforestry holding, in ha	*Farmland owner*	0.69	3.83
	Forestland owner	0.69	1.41
Mean number of plots per unit of area of the agroforestry holding, in no/ha	*Farmland owner*	13	57
	Forestland owner	6	12
Area of woodland within the agroforestry holding, in ha	*Farmland owner*	0.00	0.00
	Forestland owner	2.64	3.68
Fraction of the agroforestry holding occupied by woodland, in %	*Farmland owner*	0.00	0.00
	Forestland owner	32.3	25.6
No. of woodland plots within the agroforestry holding	*Farmland owner*	0.00	0.00
	Forestland owner	6	10
Mean size of woodland plots within the agroforestry holding, in ha	*Farmland owner*	0.00	0.00
	Forestland owner	0.84	2.17
Mean number of woodland plots per unit of area of the woodland holding, in no/ha	*Farmland owner*	0.00	0.00
	Forestland owner	5	9

Classification into *farmland* and *forestland* owners

Table 3 Parameter estimates of the discriminant analysis model that examines the factors differentiating farmer groups

Predictor	Standardised coefficients	Canonical correlation	Function coefficients
PRODUCTIVITY	0.385	0.212	0.324
SIZE	0.465	0.704	0.504
PLOT	0.690	0.837	0.907
MANAGEMENT	0.210	0.124	0.210
INCOME2	−0.142	−0.093	−0.128
Constant	–	–	−3.157
Eigenvalue			0.854
Percentage of variance			100.0
Cumulative percentage			100.0
Canonical correlation			0.743
Wilks' Lambda			0.245
Chi-square			369.574
df			4
P-value			0.000

Conversely, the eigenvalue (0.854) showed a high percentage of variation explained by the discriminant function, while taking into account the Lambda statistic value, almost 25% of the total variance in the scores of the discriminant function were not explained by the inter-group differences. Given that the level of significance associated to the Chi-square test (transformed value of the Lambda statistic) was lower than 5%, it can be stated that the centroids of the groups (mean values of the discriminant scores for each group) were different, there being no significant overlapping among them. The *farmland owners* were associated to negative discriminant scores (−0.465), while higher or positive discriminant scores were linked to *forestland owners* (0.478).

The value of the standardised coefficients for the discriminant function made it possible to verify the net individual weight of the variables included in the discrimination function between farmer groups (Table 3). The results indicated that the PLOT variable was the most significant factor when discriminating between *farmland* and *forestland owners*, given its important net contribution to the discriminant function (0.690). In a second group, with similar loadings in the discrimination function, it was the SIZE and the PRODUCTIVITY variables (0.465 and 0.385, respectively). Finally, the MANAGEMENT and the INCOME2 variables were, in that order, the factors with least relative weight in the discrimination function (0.210 and 0.142, respectively). By way of summary, there were significant differences between the *farmland* and *forestland owners* groups as regards the number of years devoted to the agricultural profession as an owner, and the economic yield from this primary activity over the total family income. Moreover, their agrarian holdings were differentiated with regard to extension and total number of plots, and the forestry production capacity of the geographic area in which they were located.

The analysis of the PLOT variable indicated that the owners who managed more than 87 plots within their holdings (4 group) had remarkably larger areas of forest than the 0 and 1 groups, with a mean difference of more than 3.32 ha of forestland within their land bases. In regard to the SIZE variable, the 5 group was characterized as owning forestlands notably larger than those owned by the remainder, except the 4 group; on average, the owners in group 5 managed 3.69 ha of forestland more than the owners in 0-3 groups. Numerous studies refer to the relevance of the extension and parcelling of the agroforestry holding in the NIPF owners' management behaviour, either in planting, silvicultural treatment, timber felling and environmental activities (Hyberg and Holthausen 1989; Hardie and Parks 1996; Kuuluvainen and Salo 1991; Munn et al. 2002; Potter-Witter 2005; Bolkesjø et al. 2007; Størdal et al. 2008; Joshi and Arano 2009). Hence, greater economies of scale would be associated to larger landholdings. On the basis of the result obtained for the study region, it could be stated that holdings with a larger land bases make it possible to conduct or implement a greater range of productive activities than with regard to holdings of smaller size, as other authors have already stated (Löyland et al. 1995; Zhang and Pearse 1997; Conway et al. 2003; Arano et al. 2004; Rodríguez-Vicente and Marey-Pérez 2008; Rodríguez-Vicente and Marey-Pérez 2009a). Moreover, as Reid and Stephen (2001) and Workman et al. (2003) have asserted, diversification in agrarian systems, as regards the inclusion of forestry areas, are manners of maintaining production, improving rural sustenance, and optimising the use of areas not devoted to agriculture.

Concerning the PRODUCTIVITY variable, its relevance when influencing the NIPF owner's forest management behaviour has been debated by Munn et al. (2002), Conway et al. (2003), Størdal et al. (2004), Arano and Munn (2006) and Størdal et al. (2008). For the region under study, those farmers with holdings located in areas of medium forestry productivity or higher (3–5 groups) were more inclined to own and manage forestland than the remaining groups, excluding 1 group. The smallest area of forestland within the holding corresponded to the 2 group, a mean of 0.76 ha; conversely, in 3–5 groups, the owners managed twice the forestland managed by the 2 group. Löyland et al. (1995) and Zhang and Pearse (1997) also verify statistically that the location of forestland is clearly more related to areas of greater forestry productivity in regions of Norway and Canada, respectively. Whereas, Álvarez-López et al. (2008) and Riveiro et al. (2008) proved how the location of agricultural holdings in Galicia was clearly related with the productivity of the land, consequently marking this primary production thereof. Johann (2007) indicates how from the mid 20th century on, the specialisation of agricultural activity in Austria has entailed important structural changes in the distribution of land resulting in the abandonment of those agrarian holdings located in areas of lower agricultural productivity, with the consequent expansion of forestry resources. The same conclusion would seem to be applicable to Galicia, since the second half of the 20th century saw important economic changes that dramatically shifted the composition, structure and area of the rural landscape (Marey-Pérez and Rodríguez-Vicente 2008). As a result, massive rural emigration and the development of a more competitive agro-livestock sector meant that a high number of agricutural holdings ceased their activity, subsequently transforming land management and land patterns

themselves. The lack of farm labour caused much land to become abandoned and progressively occupied by scrubland and native woodland (Marey-Pérez et al. 2006), depending on agriculture and the opportunities for land-use conversion. Accordingly, Table 2 shows that, although the total area and number of plots is clearly higher in the *forestland owner* group than in the *farmland owner* one, the number of parcels per unit of area is, on the contrary, clearly higher in the holdings of the *farmland owner* group.

As regards the MANAGEMENT variable, those farmers in the study having devoted more time to the management and administration of agrarian holdings were more inclined to diversify their agro-livestock activity by including silviculture (*forestland owner*) than those farmers with less professional agricultural experience, more focused or orientated towards agriculture or livestock farming exclusively (*farmland owner*). The owners in groups 4 and 5 managed notably more area of forest within their agroforestry holdings than the remaining owner population, a mean of 1.3 times larger in forestland than the 1-3 groups. A longer period of time as the owner of a holding could indicate the farmer's greater interest in forest management, encouraging him/her to conduct other long-term activities outside the sphere of agriculture and livestock farming. As Welch (1970) cites, with regard to the role of education in the productivity of workers, here we could mention that experience managing agrarian holdings would provide owners with skills for diversifying their production and administering the available resources. The above assertion could be assimilated to that indicated by Lien et al. (2007) and Joshi and Arano (2009) as regards the role of the NIPF owner's education in forestry management; a higher level of education would provide managers with a greater range of information and techniques, enabling them to be aware of the pros and cons of investing in different alternatives and they would thus be more qualified to better understand the benefits associated with forest management. Taking into account the greater experience shown by *forestland owners* in years devoted to managing agrarian holdings, along with larger sizes of holdings, we could corroborate the results provided by Evans (1987) and Summer and Young (1987), in which farmers with greater experience would choose to work larger holdings thanks to improved and greater production capacity with lower marginal costs.

Based on this final assertion, and considering the continual decline of agrarian activity in the region over recent decades, a section of the farming population may have opted for silviculture as an additional source of income for the family unit and to increase farm productivity, given an investment which is more staggered over time and with lower work requirements than agriculture (Kurttila et al. 2001; Reid and Stephen 2001; Marey-Pérez and Rodríguez-Vicente 2008; Rodríguez-Vicente and Marey-Pérez 2009a). Consequently, Lien et al. (2007) state that owners would aim to maximise the utility of a portfolio of activities, where forestry is one of several possibilities, and thus conflicting productions have to be weighed up against each other. In fact, and considering the final discriminant variable (INCOME2), the *farmland owner* group is characterised by receiving family income in which agrarian activity would have an important weight in the global calculation, in comparison with the *forestland owner* group, in which the family income would comprise certain, clearly more diversified revenues and, hence, agroforestry activity

would have a lower individual weight in the income as a whole. In figures, the 4 group had remarkably smaller areas of forestland than remainder; as mean values, owners in 1–3 groups had 1.46 ha more of forestland than owners in 4 group. Considering the owner's annual income as a measure of the intensity of land management, given that it provides a measurement of the quantity of capital that the owners choose or decide to invest in their property, the important dependence of agrarian revenue on family income in the *farmland owner* group would seem to suppose that these clearly focus their investments on agro-livestock activity, excluding silviculture, in comparison to *forestland owners*, where the diversification of income would moreover seem to contemplate the capitalisation of forestland. Adapting results provided by Vokoun et al. (2010) for the joint forestry management of neighbouring NIPF owners, we could suggest that as *forestland owners* show a declining marginal utility of income from agriculture, these owners would be less inclined to depend on their revenue from this activity and more disposed to participate in other agricultural activities (silviculture) which have the potential to interrupt planned agricultural revenue streams. In other words, and also adapting the results provided by Hyberg and Holthausen (1989) regarding NIPF owners' timber harvesting behaviour, having high economic revenue from sources outside agriculture at their disposal would determine that *forestland owners* have alternative profiles regarding the marginal utility of income from agriculture when compared to the average income in the study population.

The results of the canonical correlation (the degree of association between the predictive variables and the discriminant function) corroborated those obtained for standardised coefficients (Table 3). Considering the criteria established by Comrey (1973), only the PLOT and SIZE variables (canonical correlation higher than 0.55) would be considered factors of greater relevance in distinguishing between farmer groups. Thus, owning and administering forestland, on the part of the farming population under study, would show a strong, positive gradient with regard to factors such as the number of plots and the area of the holding. In the second group, PRODUCTIVITY and MANAGEMENT, in that order, would be positively and weakly correlated with the FOREST criterion variable, although, the aforementioned significance criteria would not be met. With the lower contribution, and without meeting the statistical significance criterion either, the value of the canonical correlation for the INCOME2 variable would seem to indicate that owning and administering forestland would be negatively and very weakly linked to the economic weight of agrarian activity with regard to the overall income of the family unit.

Table 4 shows the classification results, according to the discriminant function constructed for the test and retest samples. Using the test sample, the percentages of *farmland* and *forestland owners* correctly classified by means of the discrimination function were 63.4 and 71.1%, respectively (Table 4); i.e., the model correctly classified almost 67.3% of the farmers included in the study sample to estimate the discriminating function. On the other hand, the cross validation of the discriminant model by means of the retest sample obtained a percentage for the correct classification of 66.6% of the latter, and 61.1 and 70.5% of *farmland* and *forestland owners* in the retest sample, respectively. In summary, the joint precision of the discrimination model was, thus, 66.5% of the farmers studied in the region.

Table 4 Results from the discriminant analysis in differentiating farmer groups

FOREST variable	Group of predicted membership		Total
	Farmland owner	*Forestland owner*	
Test sample			
No.			
Farmland owner	1,125	651	1,776
Forestland owner	495	1,218	1,713
%			
Farmland owner	63.4	36.6	100.0
Forestland owner	28.9	71.1	100.0
Retest sample			
No.			
Farmland owner	278	177	455
Forestland owner	129	310	439
%			
Farmland owner	61.1	38.9	100.0
Forestland owner	29.5	70.5	100.0

Finally, the Fisher's linear discriminant functions for farmland owners (Eq. 2) and forestland owners (Eq. 3) are given below:

$$\begin{aligned} \text{FARMLAND OWNER} = & -13.219 + 3.047\ \text{PRODUCTIVITY} + 0.640\ \text{SIZE} \\ & + 1.405\ \text{PLOT} + 2.994\ \text{MANAGEMENT} \\ & + 2.356\ \text{INCOME2} \end{aligned} \tag{2}$$

$$\begin{aligned} \text{FORESTLAND OWNER} = & -16.204 + 3.352\ \text{PRODUCTIVITY} + 1.116\ \ \text{SIZE} \\ & + 2.261\ \text{PLOT} + 3.192\ \text{MANAGEMENT} \\ & + 2.235\ \text{INCOME2} \end{aligned} \tag{3}$$

Conclusions

The use, management and planning of forestry resources, as an indisputable component of a set of natural resources, is the object of international study and debate, both in terms of research and in policies on the different scales of work. Within this international debate among the public, scientists, and decision-makers, particular attention is paid to the so-called non-industrial private forest (NIPF) owners, given that these, as almost exclusive managers in many of forestry regions all over the world, have come to play a key role in the balanced integration of the variety of uses and functions of forestland in policies for promoting and revitalising rural areas. Taking into account their agro-livestock background, an important section of NIPF owners are active farmers or descendants of farmers, land managers who perform important work in land management and planning, by maintaining or

increasing the current value of the forestry sub-sector. Thus it is essential to devise public measures or incentives to encourage and support the professionalisation and socioeconomic development of these NIPF owners. Those factors which are key in the forestry management guidelines adopted must be identified beforehand to then empirically characterise and model the forestry management regime adhered to.

In line with the above premise, the present study is based on data obtained from personal interviews conducted in 2004, on a total of 4,383 professional farmers from Galicia (north-west of Spain) distinguished on the basis of the existence or not of forestland within the land base of the agrarian holding: 2,231 *farmland owners* and 2,152 *forestland owners*. Using discriminant analysis techniques, and based on a system of agroforestry information comprising 245 variables and 4,383 records, including variables of different natures related with the agrarian holdings under study (profile of the owner and the family unit, land use and agroforestry holding, and public-political measures), we identified and quantified those empirically significant factors in which a certain population of farmers opted for silviculture as a source of additional revenue to the principal income of the family unit as opposed to others, with no type of forestry activity (activity focused exclusively on the production and management of land for agriculture or livestock farming).

The results obtained show that the number of plots forming the land base of the agrarian holding was the predictive variable with the greatest weight in distinguishing between *farmland* and *forestland owners* in the study region. Thus, those NIPF owners denoted as *forestland owners* are characterised by managing holdings in which the number of plots was significantly higher than those in holdings belonging to the *farmland owner* group. Two other variables linked to the holding (its agroforestry size and the potential forestry productivity of the zone) also proved to be key factors in discriminating between farmers with and without forestland. In this case, *forestland owners* would manage agrarian holdings with a larger land base and located principally in areas of greater forestry productivity than *farmland owners*. These results could be linked to the notion that a larger land base, in terms of both area and number of plots, would make it possible to diversify agrarian production, with the manager opting for activities such as silviculture for certain plots or subplots in the holding. With regard to forestry productivity, as could have been expected, in those areas of Galicia which are highly productive from the forestry perspective, there is a greater tendency for this use to be more representative as opposed those uses which are truly agricultural or livestock ones. Finally, those variables representing the number of years the owner had administered the holding and the relative weight of agrarian activity in the family's global revenue also proved to be relevant factors in distinguishing between *farmland* and *forestland owners*. Thus, owners with greater experience with regard to managing agrarian holdings and with agrarian activity with a lower individual weight with regard to the total family income would be more inclined to diversify farm productivity through the management of forestland, possibly due to the knowledge and skills gleaned from such experience.

Forestry management within agro-livestock holdings must be viewed as an opportunity, and a responsibility, for revitalising rural areas, encouraging population settlement, protecting the environment, and generating wealth by improving

agrarian productivity. But to do so, farmers will need the knowledge, techniques and resources required to manage forestry resources, both for individual wealth and for society as a whole. This study initially suggests that it may be possible to predict and classify NIPF management under socioeconomic and ownership variables, and consequently, the results can be useful for estimating the different adjustment factors for encourage landowners -*farmland and forestland owners*- in order to more correctly design operative planning measures and project and future demands of multiple services and products from forests.

Although the principal objective of the empirical model presented in this study was to identify socioeconomic, territorial and public-political factors significant in distinguishing between *farmland* and *forestland owners*, the results of applying discriminant analysis techniques provide useful information for helping policy-makers and research groups to become acquainted with and have a better understanding of forestry management behaviour of NIPF owners who are farmers. This knowledge would permit the subsequent planning and development of tools and/or policies in a combined top-down and bottom-up procedure, related to the objectives and requirements of this population, encouraging the onset or the continuity of suitable options or forestry practices among NIPF owners with agro-livestock activity as key agents in the promotion of rural development.

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